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Handcrew Fireline Production Rates—Some Field Observations

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RESEARCH SUMMARY

This paper presents the results of a study of handcrew fireline production rates. The methods are discussed. Tables and figures show the data collected and their analysis in a variety of stratifications. The basic data from the study are also presented. Because of the limited data set of 160 observations, it was not possible to develop a detailed production model. However, the data do show some interesting relationships. The authors recommend further study to enhance these as well as previous efforts.

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INTRODUCTION

As wildland fire suppression has become more expensive and sophisticated, the need to understand the rates of fireline production has increased. Not only has the basic perspective of wildland fire suppression changed since the early 1900's and the 1930's, but the work ethic, equipment, management constraints, and other issues have changed.

Today we no longer attempt to overcome all fires with labor-intensive organizations, crosscut saws, mules and horses, steam engines, and bare guts. We now have expensive tools, ranging from D-9 size bulldozers, to multimillion dollar amphibious aircraft, helicopters of all sizes and shapes, electronic equipment, highly trained firefighters, and more. However, people still make the decisions, and people must do the work.

Because firefighters on the ground will long be the key ingredient to wildland fire suppression, we have studied how well and how quickly they build fireline in different situations. This is only a small piece of the fire suppression organization, but an important one.

PROBLEM

Past fireline production studies considered only a few variables, such as crew size, training or experience level, and some broad field classifications. These field classifications were generally geared to resistance-to-control and rate-of-spread categories. For example, a high rate of spread and medium resistance to control were translated into a H-M fuel situation. The fireline production rates for equipment were handled in a similar fashion, using machine size and type along with some sort of fuel classification scheme. Occasionally, operator experience levels were also used to help delineate the production rate potential.

With today's high resource values, current policies, and the extremely high cost of fighting wildland fires, simplistic approaches to determining fireline production rates are no longer acceptable. Suppression capabilities need to be expressed in terms allowing more sophisticated analysis and application. In addition, we need applications for situation analyses, management objectives, economic criteria, and impact assessments. Research must be compatible with data synthesis and analysis techniques. Furthermore, recent developments in fire models, fire-danger rating, and economic evaluation procedures require expanded, more accurate, fireline production information. Various suppression capabilities and new suppression rules need to be linked to fire characteristics, including site and fire behavior.

PAST AND CURRENT WORK

Fireline production information has been developed since before the turn of the century. However, in the mid-1930's a considerable amount of information surfaced. This may have been due in part to the formal beginning of fire research as well as the need for better data to support "new" Forest Service policies. Hornby (1936) developed a list of factors considered most important in held fireline constructed per person per hour:

1. Fuel resistance to control
2. Method of attack
3. Kinds of tools, equipment, and food provided
4. Efficiency of directing officers
5. Training and experience of firefighters
6. Physical and mental ability of firefighters
7. Size of crew
8. Size of fire
9. Aggressiveness and heat of fire
10. Prevailing atmospheric temperature
11. Fatigue
12. Darkness

These items seem just as appropriate today with some slight modifications of terminology. Work of Abell (1937), Buck (1938), and Hanson (1941) provides additional data on fireline production rates. In 1969, Storey summarized existing productivity and line building data. Although considerable handcrew data were available, he felt their quality was questionable. Bulldozer data were in similar condition. Storey wrote:

Solutions of force required to suppress a fire obtained from dispatching and probability guides in the fireline notebook are only as good as the data on fire spread and force productivity on which they are based. As we have seen, force productivity data are limited in quality and coverage. Estimates of length of fireline requiring treatment are of limited accuracy due to a general lack of good data on fire behavior. Models of fire spread and control will require much better data on fire spread and force productivity than currently exist. Fire behavior studies are currently underway that should provide better data in the near future. It is recommended that they be continued and, if possible, accelerated.

In order for mathematical models of fire behavior and control to be applicable nationwide, systems for rating fuels and weather from a fire effect standpoint must be applicable nationwide. Good progress is being made on a national fire danger rating system. A study to develop a national system for rating fuel for rate of spread and resistance to control is underway but not as far along. Such a system is urgently needed.

In addition to Storey's summary, several studies have been made of fireline production. These range from the theoretical studies of McMasters (1963) to more recent handcrew studies of the California Department of Forestry (Weaver 1976). Some of the complaints with earlier studies, such as inadequate ties to conditional and site variables, also apply to the more recent efforts. Barney and Noste (1973) attempted to tie both crew and machine efforts to conditional and site parameters in Alaska, but only a limited amount of data was collected. In the early 1970's, Lindquist developed some crew production data. But this work was not tied to environmental, site, or other conditioning factors. Production rates for various line widths were determined.

In the middle and late 1970's the Equipment Development Center, Missoula, MT (Ramberg 1974) carried out some fireline production studies in conjunction with firefighter fitness and physiology research. They concluded that fireline production rates in current field guides were too high in most cases. Murphy and Quintilio (1978) developed crew production rates that included some details for fuels and construction resistance. Haven and others tried to make sense out of the production data in 1982. They assembled much of the past data and updated Storey's work. They also developed conceptual approaches to get at the problem, but did not provide any additional hard data. Barney (1983) discussed a conceptual approach for fireline production information, outlining elements that modify a base rate. This rate can go up or down. These changes can be caused by factors ranging from environmental conditions to organization, to equipment and manpower limitations.

Recently, Quintilio and others (1988) and Murphy and others (1989) tried to quantify initial attack production information. These data broke away from the traditional concentration on dug fireline, concentrating instead on initial attack hot spotting. Fried and Gilless (1989) studied the expert opinion approach. They found previous production rate data were optimistic, compared to survey-type production rate information. They felt expert opinion provided information and another useful tool.

The literature does not include measures of production rates relative to containment or suppression goals, efficiencies of personnel use, or economic objectives. One notable exception is the work by Murphy and Quintilio in 1978. The assumption that you always do what is needed at the time for the job may not be appropriate today.

STUDY OBJECTIVES

The study sought to determine the basic relationships between suppression capabilities, fire characteristics, and situation parameters on handcrew fireline production rates. Specifically, the objectives were to:

1. Determine rates of crew fireline production for several crew and tool configurations.
2. Establish basic crew-production relationships based on specified situation parameters.
3. Develop operational and planning support information using established rates and relationships.

This study sought to develop relationships that were nationally applicable. The information was to assist field applications and long-range planning. Initial efforts were concentrated in the Intermountain West, but were designed to satisfy as wide a range of conditions as possible. The study was segmented into smaller components. The amalgamation of these components helps provide solutions to the broader problem. The study began during the 1982 summer field season. Initial procedures, forms, and approaches were tested that year. Actual fire data and simulated information were gathered. Most simulated data were collected while crews prepared firelines around cutover areas that were burned later. After that first season the limited information was analyzed. The field data collection form was modified for the following field season. We attempted to do a majority of the fieldwork ourselves. However, we soon found we would not get enough data. Data forms and instructions were provided for crews willing to collect information throughout the Western United States and Alaska. We trained observers whenever possible. The study took place during the next two field seasons. The study was shelved in 1985 due to research program changes. The study was reactivated to close it out with a detailed report. This makes the information available to managers and researchers alike.

Table 1—Descriptive statistics for selected variables

Variable	*n*	Minimum	Maximum	Mean	Standard deviation
Crew size	160	1.0	40.0	11.66	8.39
Slope	160	.0	99.0	41.86	27.91
Line width (ft)	157	.2	8.0	2.16	1.23
Clearing width (ft)	158	.0	75.0	5.61	8.97
Production rate (ft/min)	172	.5	50.0	8.10	9.11

METHODS

Data Collection

Field observations included simulated and actual fireline construction. In the simulated situations, crews were observed building line around prescribed burn units before ignition. We also built line during training exercises. In these cases, the crews were instructed to work as if they were just beginning a full shift with 8 to 10 hours of work ahead of them. This was to avoid "over production" because the crew wanted to look good for the study. Crew bosses were consulted to be sure they felt the pace could be sustained throughout the shift with normal breaks and meals. We observed for at least 15 minutes or until at least 50 feet of line had been dug. When fuel type, soil, or line grade changed, new observations were begun. For example, if a line being constructed in a mature timber stand with downed material moved to a brushfield, the observation would be completed for the timber and a new observation begun for the brushfield.

Both researchers and fire managers made observations. Fire managers usually filled in the forms when they had a chance while training or while fighting a fire. Observers completed a field form (appendix A) for each observation. Each observer was given instructions to fill out the form (appendix B). Whenever possible, a researcher trained the observer. The forms were collected at the fire laboratory and coded for computer analysis.

Coding instructions are in appendix C. During data entry, we calculated the rate of fireline construction by dividing the length of line constructed by the time required. These data were entered and verified for analysis. Although the study focused on trained interregional crews and smokejumpers, other crews were used.

Data Analysis

Descriptive statistics for the data were developed for several variables thought to have the greatest effect on fireline production rates. Table 1 shows some of the data elements used in analysis.

Crew sizes ranged from one to 40. Many observations were of crews with 18 to 20 firefighters, the normal IR crew size. The average size of the crews observed was 11.66. Crew size depends on the type of crew (figs. 1-6). The hotshot crews for simulated line

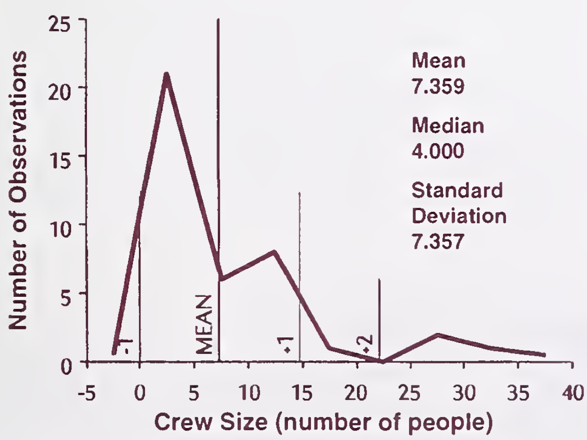

Figure 1—Number of observations for different sizes of smokejumper crews. Negative numbers are an artifact of frequency distribution.

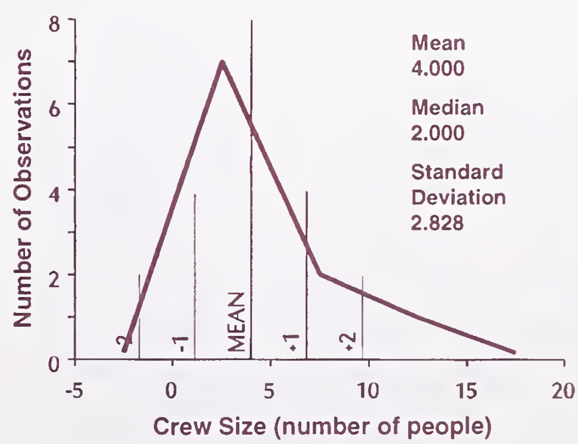

Figure 2—Number of observations for different sizes of helitack crews. Negative numbers are an artifact of frequency distribution.

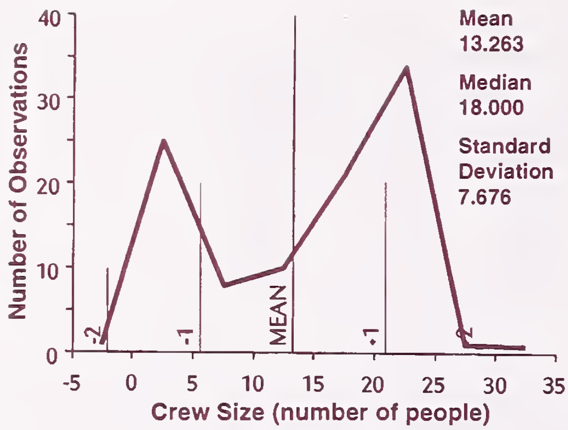

Figure 3—Number of observations for different sizes of hotshot (IR) crews. Negative numbers are an artifact of frequency distribution.

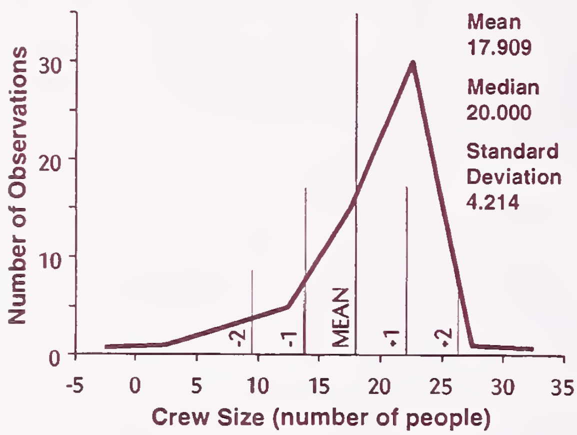

Figure 4—Number of observations for different sizes of hotshot (IR) crews on ongoing fires. Negative numbers are an artifact of frequency distribution.

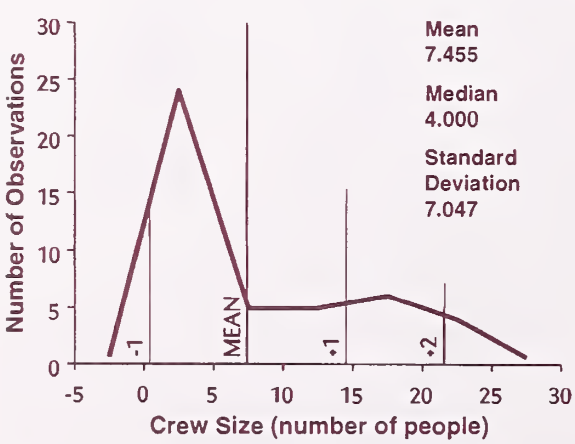

Figure 5—Number of observations for different sizes of hotshot (IR) crews in simulated situations. Negative numbers are an artifact of frequency distribution.

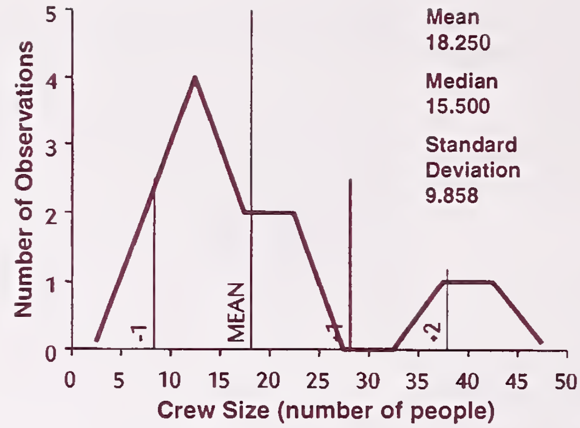

Figure 6—Number of observations for different sizes of crews other than smokejumper, helitack, and hotshot (IR). Negative numbers are an artifact of frequency distribution.

construction were often small, one to four firefighters. In actual fire situations, the crews normally included 18 to 20 firefighters. Smokejumper crews were generally smaller than 10.

Firelines were constructed on slopes ranging from 0 to 99 percent. The average slope was about 40 percent. Fireline width ranged from 0.2 to 8 feet with the average just over 2 feet, about two shovel widths. The fireline clearing width ranged from 0 to 75 feet, averaging slightly over 5 feet. Where there was no clearing, the clearing width was recorded as 0. This was the case in most simulated observations. Measured production rates ranged from 0.5 foot per minute to 50 feet per minute. This is from 30 feet per hour to 300 feet per hour (about 0.5 chains per hour to slightly over 4.5 chains per hour).

Table 2 shows the observations by crew types. Almost all (86 percent) of the observations were of Type I crews (hotshot and smokejumpers). The hotshot (IR) crews were used for all 1982 observations and in most simulation tests. After data for this study had been gathered, the abbreviation for Interregional hotshot crews (IR) changed to IH. This paper uses IR, the abbreviation in use when the data were gathered.

Table 2—Observations by crew type

Crew type	Frequency	Percent
Smokejumper	39	24.4
Helitack	10	6.2
Hotshot (IR)	99	61.9
Trained, native	1	.6
Trained, other	5	3.1
Other	6	3.7

Table 3—General fuel type where fireline was constructed

General fuel type	Frequency	Percent
Conifer—mature	83	52.2
Conifer—young	5	3.1
Hardwood—mature	4	2.5
Hardwood—young	1	.6
Mixed conifer/hardwood—mature	10	6.3
Mixed conifer/hardwood—young	2	1.3
Grass and brush	49	30.8
Grass and weeds	5	3.1

The general fuel types encountered in the study were predominantly mature conifer and grass and brush types (table 3). We did not use fire danger rating or fire behavior fuel models for several reasons. The most important was that field crews were not able to use either adequately during the study.

The cover types in which the fire was burning or the line was dug were primarily composed of four broad fuel type categories: shrubs and brush, litter and debris, weeds and grass, and subsurface. Table 4 shows the distribution.

The primary ground materials encountered in fireline production were mineral soil and rocky material, comprising 83 percent of the total. Alpine tundra accounted for slightly over 11 percent. The most common soil types encountered were: light rocky, 28.8 percent; medium rocky, 28.8 percent; loam, 11.9 percent; heavy rocky, 9.4 percent; sandy, 8.8 percent; and clay, 3.1 percent.

The type of fireline primarily included five categories. Line cleared to mineral soil was 37.1 percent. Mineral soil line with additional clearing was 21.4 percent. Mineral soil line with additional clearing and limbing was 11.9 percent. Scratch line, a quick, rough and dirty line, was 10.1 percent. Black line, line that was burned out, was 10.1 percent.

The data collected seem to have covered a representative cross-section of the fuels and conditions encountered in the field. However, some fuel type subcategories have many observations, while others have few or none. This limits the conclusions that can be drawn from the data set.

Table 4—Fuel type where fire was burning or line was being dug

Fuel type	Frequency	Percent
Tree crowns	5	4.8
Shrubs and brush	36	34.6
Weeds and grass	17	16.3
Litter and debris	24	23.1
Slash	6	5.8
Alpine tundra	3	2.9
Subsurface (peat, etc.)	10	9.6
All strata	3	2.9

In the first year of the study, the data were collected mainly by researchers, while in later years fire managers were trained to help. This may have added an extra variable to the study. There may also be some difference between the actual and simulated data.

An analysis of variance showed that the means of the annual production rates were different for the 3 years of study. This could be attributed to observer differences. However, because the data were collected opportunistically, the difference in the means may be due to other variables. Because of the limited amount of data, we pooled all data, even though the analysis suggested a statistical difference between years. By pooling the data, we were able to maximize the number of observations for each stratification.

An analysis of variance showed that the mean production rate for the actual fires did not differ significantly from the rate for simulated situations. Frequency distributions for the actual and simulated production rates are shown in figures 7 and 8. Figure 9, a plot of the production rate by number of persons in the crew, supports pooling both types of information.

The data were subjected to a series of regressions and analyses of variance. Both simple and multiple step-wise regression analyses were used. We made runs with production rate as the dependent variable and crew size as the independent variable. Each run was stratified by other variables of interest, such as fuel type, soil type, and slope. We also attempted to make a more complete model for predicting line construction using additional variables. In addition, the data were plotted on graphs.

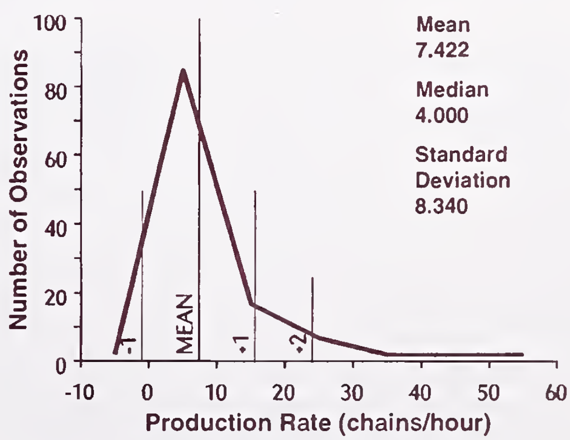

Figure 7—Frequency distribution for the fireline production rates observed during ongoing fires. Negative numbers are an artifact of frequency distribution.

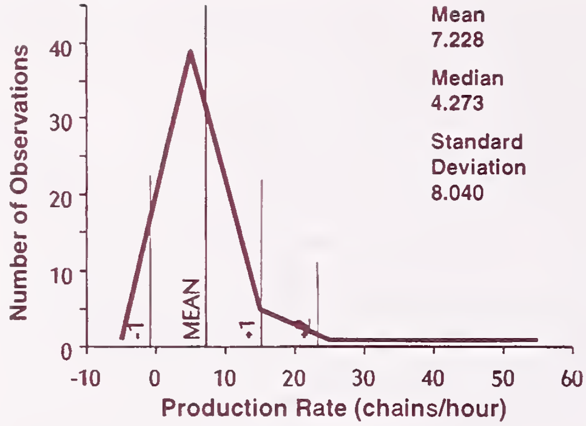

Figure 8—Frequency distribution for the fireline production rates observed during simulated situations. Negative numbers are an artifact of frequency distribution.

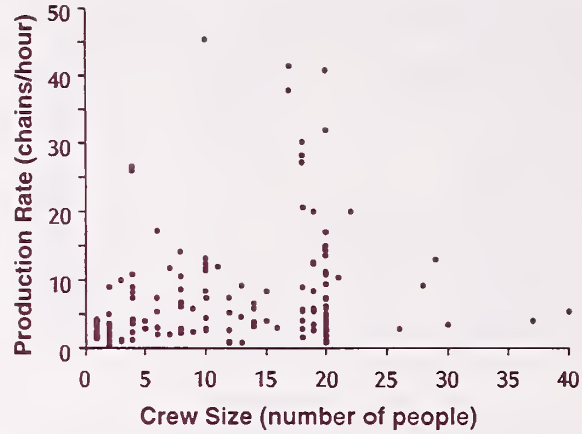

Figure 10—Fireline production rates with different crew sizes.

DISCUSSION

After analysis, we assessed the results to determine how useful they would be to the fire manager in the field and for planning. In general, we feel the results include good basic information about fireline construction and its relation to numerous variables. However, the data set contained only 160 observations. The data set is too small to draw firm conclusions on the relationships between variables, considering the extreme variation encountered. Most of the relationships we studied appeared to be reasonable. The underlying problem is the extreme variation or study "noise" encountered and the smaller data sets after stratification. After considerable computer time, we selected those relationships we feel are most useful.

The data were plotted using production rate as dependent variable and size of crew as the independent variable (fig. 10). The general production rate flattens off as crew size increases. As a crew becomes larger, there appears to be an interaction which decreases the total production rate. However, larger crews appear able to sustain their rate of production over a longer period of time.

The data were further stratified by fuel type and crew type. A graph has been plotted for that data. We also plotted the current fireline production data for sustained line production found in the NWCG Fireline Handbook (NWCG 1989) for comparison. The study data were further grouped to simplify the entire process. We grouped the study fuel types as shown in table 5. This table also shows the relationship we chose with the handbook fuel models.

Figure 9—Comparison of fireline production rates with different crew sizes for simulated and ongoing fire situations.

Table 5—Fuel model groupings and equivalents

Study fuel type, general	NWCG 1990 fire behavior fuel model
1 - Conifer, mature 2 - Conifer, young	6 - Dormant brush/ hardwood slash 8 - Closed timber litter 10 - Timber (litter and under)
3 - Hardwood, mature 4 - Hardwood, young	9 - Hardwood litter
5 - Mixed, mature 6 - Mixed, young	8 - Closed timber, litter 9 - Hardwood litter
7 - Grass and brush	5 - Brush (2 ft)
7 - Grass and brush 8 - Grass and weeds 9 - Tundra, tussock 10 - Tundra, alpine	1 - Short grass 2 - Open/grass understory 3 - Tall grass 5 - Brush (2 ft)

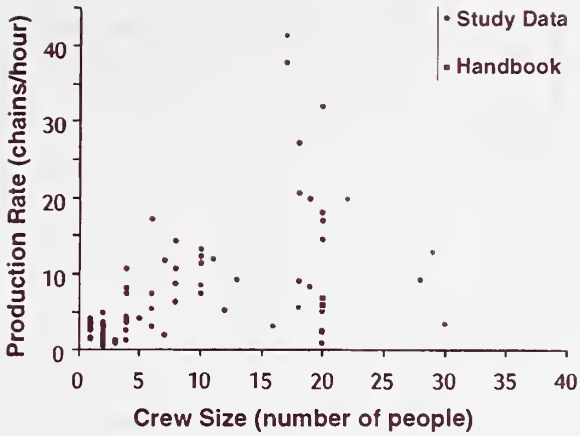

Figure 11—Fireline production rates with different crew sizes for conifer fuel models and smokejumper and IR crews.

Figure 13—Fireline production rates with different crew sizes for hardwood fuel models and smokejumper and IR crews.

In figure 11 we plotted data for fireline production rates in the conifer fuel type with smokejumpers and hotshot crews combined. Output generally increases with increasing crew size up to about 20. The handbook values plotted on this same graph are similar, but perhaps slightly lower than our data. Looking at these same data for all crews other than types 1 and 3, the production rate is generally lower (fig. 12). The handbook data are similar, but slightly lower. This production curve is much flatter than the crew type 1 and 3 data in figure 11.

Such a difference seems reasonable, since both the smokejumpers and the hotshot crews are experienced, highly trained, highly motivated, and in excellent condition.

Figure 13 shows the data for study fuel models 3 and 4, the hardwood models. Our data are considerably lower than those in the Fireline Handbook. This is partly due to limited data. Our data are from western hardwoods, primarily aspen stands. We suspect that the understory is much different than that found in the dominant hardwood stands of the Eastern and Southeastern United States from which the handbook rates were derived.

Fuel models 5 and 6 (mixed conifer-hardwood) for all crew types show production rates much lower than the handbook's. These wide variations could be a result of fuel type definition and limited data. Figures 14 and 15 compare our data and the handbook's for this fuel type. The information is limited, so it should serve only as a general comparison.

Figures 16 and 17 compare our grass and brush data with the fire behavior model for short brush, model 5. The handbook value is right in the middle

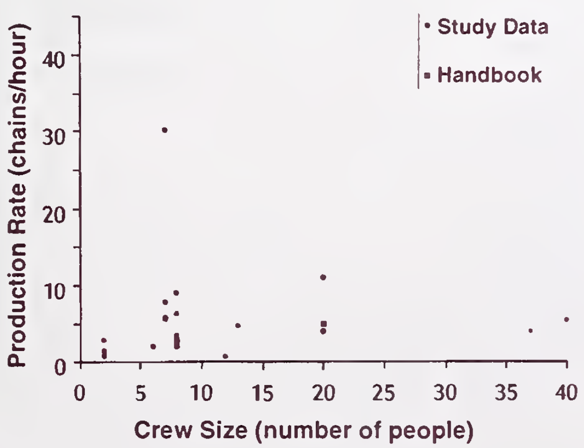

Figure 12—Fireline production rates with different crew sizes for conifer fuel models and crews other than smokejumper or IR.

Figure 14—Fireline production rates with different crew sizes for mixed fuel models and smokejumper and IR crews.

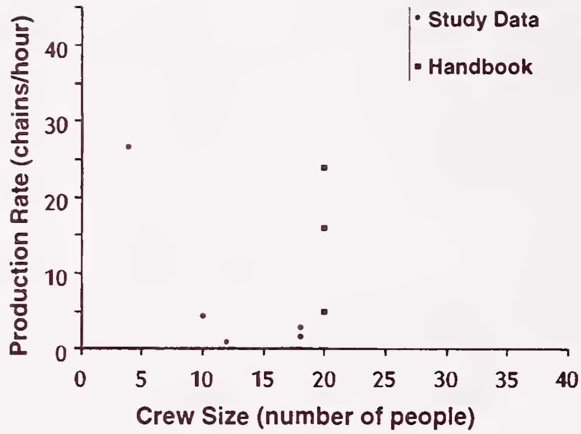

Figure 15—Fireline production rates with different crew sizes for mixed fuel models and crews other than smokejumper or IR crews.

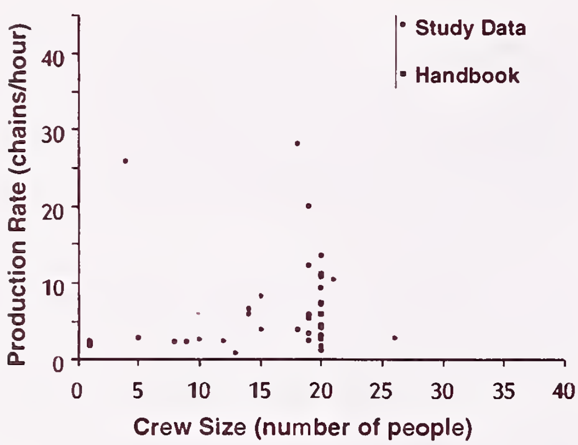

Figure 16—Fireline production rates with different crew sizes for grass and brush fuel models and smokejumper and IR crews.

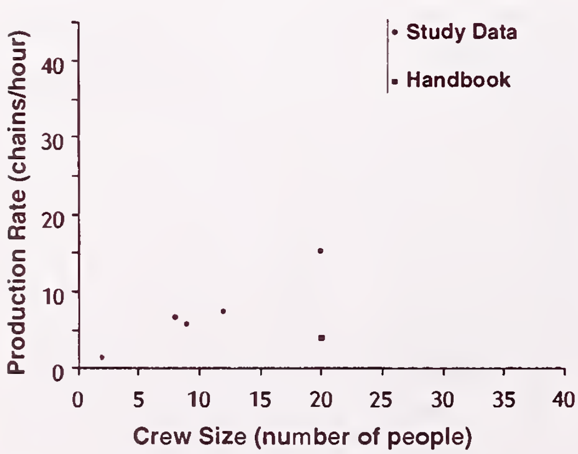

Figure 17—Fireline production rates with different crew sizes for grass and brush fuel models and crews other than smokejumper or IR crews.

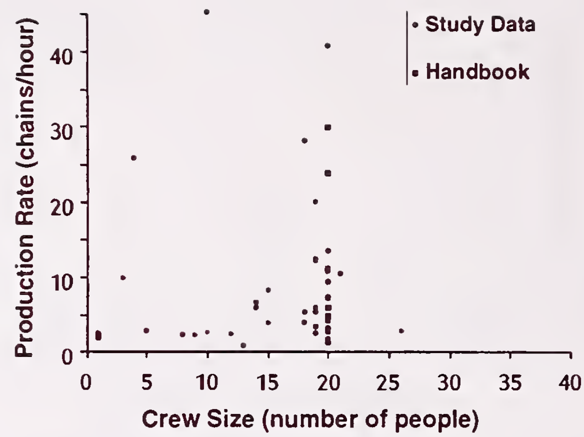

Figure 18—Fireline production rates with different crew sizes for grass, brush, and weed fuel models and smokejumper and IR crews.

of our data for crew types 1 and 3. However, for the remaining crew types, our data are higher than the handbook's for this fuel type.

When we pool the study data for our grass fuel types 7 and 8, comparing it to the handbook models 1, 2, 3, and 5, we find considerably more spread. The data are still within the ranges of our information for crew types 1 and 3 (fig. 18). In looking at the data for all other crew types, we had only one observation at the 20-person crew size (fig. 19). The trend of our data generally supports the handbook values.

Fireline production is faster in mineral soil (fig. 20) than in rocky ground material (fig. 21), as would be expected. The alpine tundra type (fig. 22) of ground material falls somewhere in between. This appears reasonable since alpine tundra resembles a combination of the two other types.

Figure 19—Fireline production rates with different crew sizes for grass, brush, and weed fuel models and crews other than smokejumper or IR crews.

Figure 20—Fireline production rates with different crew sizes for mineral soil ground materials.

Figure 21—Fireline production rates with different crew sizes for rocky ground materials.

Figure 22—Fireline production rates with different crew sizes for alpine tundra ground materials.

Figure 23—Fireline production rates with different crew sizes for sandy soil types.

Specific soil types were also assessed. Figures 23 through 27 show the production rate and crew size relationship by soil types. All show the rate of production generally increasing with additional crew members. Data scatter and relatively small sample sizes do not allow hard conclusions to be drawn. With the shift in soil texture from sandy to rocky, the data seem to show decreasing output. This fits our general experience and previous studies, including Murphy and Quintilio (1978).

SUMMARY AND CONCLUSIONS

After comparing our data to previously collected data and current handbook values, we are confident our information can help adjust production rates. Some stratifications have enough information to develop new production curves and tabular values. One

Figure 24—Fireline production rates with different crew sizes for loam soil types.

Figure 25—Fireline production rates with different crew sizes for light rocky soil types.

Figure 27—Fireline production rates with different crew sizes for heavy rocky soil types.

Figure 26—Fireline production rates with different crew sizes for medium rocky soil types.

of the remaining problems is definition of variables. We find considerable variation in almost all elements of interest. When we pool several elements to develop a model, the general scatter increases. This should not keep anyone from using the information, but should serve as a caution that the expected rate of production may vary widely. Fire managers must continue to be aware of the variability of the data and the models, applying them accordingly. The data from this study are available in appendix D so fire managers and researchers can use them as the need arises.

RECOMMENDATIONS

Considerably more data are needed to develop more complete fireline production models. The data from this study can provide improved tabular values for applications in handbooks and calculated rates for computer applications. We will continue to need more precise information for Expert Systems and Artificial Intelligence fire management applications.

Further study of fireline productivity is needed for more rigorous analysis and for inclusion of all primary variables. This study's basic format was appropriate. But we didn't collect as much data as we had estimated. The definitions of variables need to be clearer and more precise. Photos would be of considerable value here. The use of one trained observer per crew would further enhance the data consistency and quantity.

The data needed to develop adequate fireline production rate models likely can be obtained at limited cost with agency support. A few individuals in fire organizations could be assigned to fire crews as data collectors while performing limited suppression duties. Such studies, set up on a broad geographic basis, with the cooperation of several agencies, would provide a significant amount of data in a relatively short time. These data would provide the solid foundation needed to make better, more cost-effective fire management decisions.

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APPENDIX A: FIELD FORM

INT-2107-01-1 (Rev. 83)

CREW FIRELINE PRODUCTION STUDY

Field Data Collection Form

OFFICE USE ONLY

Coded Information

I. Identification

1. Fire name ______
2. Date ______
3. Time ______ Hrs.
4. Agency ______
5. Observer ______ (Name, position)

II. Crew Description

1. Number of persons ______
2. Tools:

   Type ______ How many? ______

3. Type of crew ______
4. Experience level ______
5. Hours on line (this shift) ______
6. Total days on this fire ______

III. Fire Weather and Fire Danger

1. Temperature ______ . ______ °F °C (circle one)
   (wet) (dry)
2. Humidity ______ (%)
3. Wind speed ______ 20' std. mph kph (circle)

IV. Fuel and Topography

1. Fuel type, general ______
2. Fuel type, burning ______
3. Ground material ______
4. Duff depth ______ inches cent. (circle one)
5. Slope ______ (%)
6. Soil type ______
7. Number of logs larger than 6" ______
8. Number of logs 3" to 6" ______

OFFICE USE ONLY

V. Type of Line Construction

1. Line width ______ feet
2. Clearing width ______ feet
3. Direction of line construction ______
4. Fireline grade ______ (%)
5. General type of line ______

VI. Fire Behavior

1. General character ______
2. Flame length ______ feet
3. Flame depth ______ feet
4. Rate of spread ______ ft/min

VII. Observation

1. Length of line constructed ______ feet
2. Time to construct ______ min.

VIII. Travel

1. Travel time to fire ______ hours
2. Mode of travel ______

Remarks:

APPENDIX B: GENERAL FIELD INSTRUCTIONS

GENERAL INSTRUCTIONS

FOR

HAND-CREW FIRELINE PRODUCTION

DATA COLLECTION

(Revised 1983)

STUDY

INT-2107-01-1

Prepared by

Richard J. Barney

April 1983

Fire Research is trying to increase information on fireline production rates. To do this, we need new field data from actual production situations. You have been requested to help us collect some of this needed data. The task is quite simple, but will require a couple of minutes for each record form. We suggest that, before you begin gathering data, you look over the data-recording form carefully. Once you have reviewed the form, please read the instructions for preparing the form so you will know the specific information needed. Data can be collected for entire crews, by squad, or whatever breakdown is most convenient. Be sure to enter the proper data under II, "Crew Description", for each observation.

When actual observations are made, be sure the shortest time considered is not less than 15 minutes of line construction, or else that the length of line is at least 50 feet. When a change in fuels, soil, grade (or other) is fairly great, end the observation and start a new one. For example, if the line is being built uphill on a 10-20 percent grade which then changes to a 60-70 percent grade, we would like the observation completed and a new one started. Another example for change would be if you were building line in a down-timber area and then came into an open grass area. You would then complete one form and start another, beginning in the new (grass) fuel type.

As the observer, you must use your best judgment to determine when conditions are similar and when they change. Each observation (or form) should be for a condition as similar as possible, either traveling 50 feet or lasting 15 minutes. Remember, if you do a good, careful job, we will have good data. If you get sloppy, you won't be helping yourself or other fire management personnel. Help us to help you; do a good, careful job.

Do the best you can to fill in all the blanks. Please do not code them on the right-hand side of the form. We will code them later. If a data item is missed, leave it blank. Please don't fake information just to fill a blank. If you miss or cannot collect a piece of data, just leave it blank.

We appreciate your help. Thanks.

(con.)

Instructions for Preparation and Coding of the
Crew Fireline Production Study
Study INT-2107-01-1

FIELD DATA COLLECTION FORM

General. One form will be prepared for each observation made. All applicable blanks will be filled in on the left-hand side of the form at the time of each observation. NOTE--A new observation will be initiated whenever a change in fuel, ground conditions, slope, or crew occurs. Minimum observations will be 15 minutes or 50 feet of line construction.. Coding will be done later by evaulators.

I. Identification

1. The name of the fire and/or agency fire number, if available, will be entered in the first block.
2. Date. The date will be entered as June 6, 1983.
3. Time. Use 24-hour clock time; e.g., 1:35 pm is 1335.
4. Agency. Enter agency name--Forest Service, BLM, State, etc. Enter area, also; i.e., Ninemile R.D., Galena area, etc.
5. Observer. Enter the name of the person making the observation. In case we need more information, we'll know who to contact.

II. Crew and Equipment Description

1. Number of persons. Enter the number of persons in the crew being observed.
2. Types and numbers of tools. Enter the number and type of tools being used; such as:

Pulaskis	Motorized hand tools
Shovels	Chain saws
Backpack pumps	Other (specify)

3. Type of crew. Enter the type of crew observed:

Smokejumper	Trained, other
Helitack	Pick-up
Hotshot (IR)	Other (specify)
Trained, native	

4. Experience level (crew, general). This is the general or average years of experience, considering all crew members:

New	3 years
1 year	4 years
2 years	Etc.

5. Hours on line (this shift). Enter to the nearest whole hour the amount of time the crew has been on-shift today, prior to the observation.
6. Total days on this fire. Enter total number of days crew has been on this fire.

III. Fire Weather and Fire Danger Data. Enter these items, if available, from either the fire FBO, or closest fire-danger rating station. Measurements on line are preferred.

1. Temperature dry bulb or wet bulb degrees C or F (specify which)
2. Humidity (percent)
3. Wind speed. Enter fireline 20' equivalent wind speed directly in MPH or KPH (specify which).

IV. Fuel and Topography

1. Fuel type, general. Record as follows:

Conifer--mature
Conifer--young
Hardwood--mature
Hardwood-young
Mixed conifer-hardwood--mature
Mixed conifer-hardwood--young
Grass and brush
Grass and weeds
Tussock tundra
Alpine tundra

2. Fuel type, burning. Record from the following types:

Tree crowns
Shrubs and brush
Weeds and grass
Litter and debris
Slash
Tussock tundra
Alpine tundra
Subsurface (peat, etc.)
All strata
Intermediate and surface strata

3. Ground material you are digging in (examples):

Mineral soil	Bog
Rocky	Frozen ground
Deep moss	Peat
Tussock tundra	Alpine tundra

4. Duff depth. Enter the depth of organic material where you are digging. Use inches or centimeters (specify which).
5. Slope percent. Enter the percent slope as measured in the direction of line construction.

(con.)

6. Soil type you are digging in. Use the following categories:

   - Sandy
   - Clay
   - Loam
   - Gravel
   - Light rocky (occasional rocks)
   - Medium rocky (10-50% rocks)
   - Heavy rocky (51-75% rocks)
   - Rocky (75%+ rocks)
   - Peat or heavy organic
   - Frozen/permafrost

7. Number of logs greater than 6" in diameter over the entire observation. Enter the number of logs greater than 6" in diameter that were cut during this observation.

8. Number of logs 3" to 6" in diameter over the entire observation. Enter the number of logs 3" to 6" in diameter that were cut during this observation.

V. Type of Construction

1. Line width. Enter the width of the actual fireline to the nearest half foot.

2. Clearing width. If fuel is cleared in addition to the line constructed above, enter the width of the clearing to the nearest foot.

3. Direction of line construction. Note the general direction of line construction, as follows:

Upslope	Angle, down
Downslope	Cross slope or level
Angle, up	

4. Fireline grade. Enter average grade of actual fireline constructed; i.e., 15 percent uphill is +15; 10 percent downhill is -10; etc.

5. General type of line:

   - Scratch
   - Wet line
   - Black (burned-out)
   - Reinforced (scratch and burn, retardant, etc.)
   - Mineral soil
   - Mineral soil w/additional clearing
   - Mineral soil w/clearing and limbing
   - Retardant only
   - Mineral soil reinforced w/retardant
   - Other (specify)

VI. Fire Behavior

1. General. Enter the general type of fire behavior nearest to the section of line where you are working, as follows:

Smoldering	Spotting
Creeping	Crowning
Running	

2. Flame length. Enter the average flame length to nearest half-foot.

3. Flame depth. Enter the depth of the flaming zone to the nearest foot.

4. Rate of spread. Record a measured rate of spread (a 5-minute observation, minimum) in feet and tenths of feet per minute; i.e., 3.5.

VII. Observation

1. Length of line constructed. Enter to the nearest foot the length of line constructed during the specific observation.

2. Time to construct. Enter the time in hours and minutes or just total minutes required to construct the line measured in 1, above; i.e., 1 hr. 24 min. or 84 min.

VIII. Travel

1. Travel time to fire. Enter the length of travel time to the fire, to the nearest whole hour, beginning when the entire crew began traveling together.

2. Mode of travel. Enter the type of travel used for the major distance traveled to the fire, such as follows:

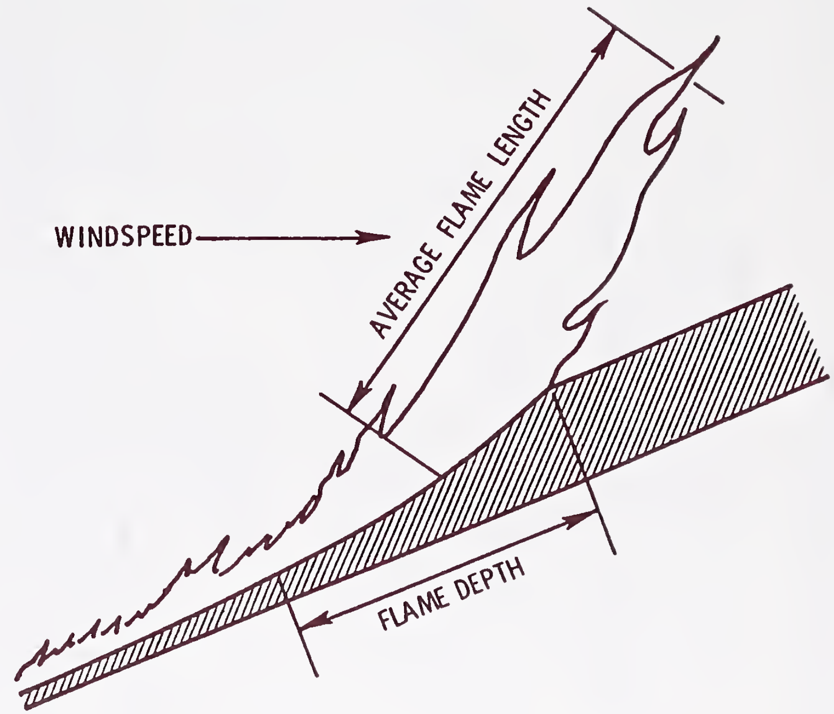
Walk	Tour (type) bus
Horseback	Truck
Airplane	Auto or pickup
Helicopter	Boat
School bus	Etc.

Remarks. Enter any pertinent information not previously covered in this section; such items as "Lost line due to wind shift; otherwise would have held;" "Well-trained and hard-working crew;" "Supervision of crew is apparently weak;" "bus broke down; otherwise could have taken more measurements;" etc. NOTE-- Briefly describe what the crew had been doing during the 24 hours prior to this observation; for example, "Up all night, awaiting transportation," or "Regular 12-hour shift following 8 hours of sleep and rest," etc.

(con.)

APPENDIX B (Con.)

The following diagram shows the measurements or estimates needed to fill in item 2, flame length, and item 3, flame depth, under part VI of the Fire Behavior Form.



Flame dimensions shown for a wind-driven fire on a slope

APPENDIX C: DATA CODING INSTRUCTIONS

DATA CODING INSTRUCTIONS

FOR

CREW FIRELINE PRODUCTION STUDY

FIELD DATA COLLECTION FORM
INT-2107-01-1 (Rev. 83)

Study

INT-2107-01-1

Prepared by
Richard J. Barney
June 1983

Instructions for Coding the Crew Fireline Production
Study Data from the Field Forms

General. The data are already on the field forms. All that remains is to provide the proper codes in the right hand column of the field forms in preparation to entering into the computer. Code the data as indicated in the blanks provided as indicated below.

I. Identification
   2. Date. Enter the date for July 5, 1983 as 070583, etc.
   3. Time. Enter the time to the nearest whole hour using the 24 hour clock. 0845 = 09, 1317 = 13, etc.

II. Crew description
   1. Number of persons. 2 = 02, 15 = 15, 20 = 20, etc.
   2. Tools.

Type	Pulaskis = 1	Motorized handtools = 4
	Shovels = 2	Chainsaws = 5
	Backpack pumps = 3	Other = 6

   How many? Enter the number as 2 = 02, 10 = 10, etc.

   3. Type of crew

Smokejumper = 1	Trained, Native = 4	Other = 7
Helitack = 2	Trained, other = 5	
Hotshot (IR) = 3	Pick-up = 6	

   4. Experience level

New = 1	3 year = 4
1 year = 2	4 year = 5
2 year = 3	Etc.

   5. Hours on line

1 hour = 1	9 hours = 9
2 hours = 2	Above 9 hours = 0

   6. Days on this fire

1 day = 1	10 days = 10
2 days = 2	Etc.

(con.)

III. Fire weather and fire danger
1. Temperature. Enter dry temperature in Degrees F. Over 99 is 99
2. Relative humidity. Enter percent RH. 5% = 05, 23% = 23, etc.
3. Wind speed. Enter in MPH. 3 = 03, 10 = 10, etc.

IV. Fuel and topography
1. Fuel type, general
   - Conifer - mature = 1
   - Conifer - young = 2
   - Hardwood - mature = 3
   - Hardwood - young = 4
   - Mixed conifer/hardwood - old = 5
   - Mixed conifer/hardwood - young = 6
   - Grass and brush = 7
   - Grass and weeds = 8
   - Tussock tundra = 9
   - Alpine tundra = 0
2. Fuel type, burning
   - Tree crowns = 1
   - Shrubs and brush = 2
   - Weeds and grass = 3
   - Litter and debris = 4
   - Slash = 5
   - Tussock tundra = 6
   - Alpine tundra = 7
   - Subsurface (peat, etc.) = 8
   - All strata = 9
   - Intermediate and surface strata = 0
3. Ground material
   - Mineral soil = 1
   - Rocky = 2
   - Deep moss = 3
   - Tussock tundra = 4
   - Bog = 5
   - Frozen ground = 6
   - Peat = 7
   - Alpine tundra = 8
   - Other = 9
4. Duff depth. Enter to the nearest inch the duff depth. 1" = 1, 9" and above = 9
5. Slope. Enter the percent as 20% = 20, 99% and above = 99
6. Soil type
   - Sandy = 1
   - Clay = 2
   - Loam = 3
   - Gravel = 4
   - Light rocky = 5
   - Medium rocky = 6
   - Heavy rocky = 7
   - Rocky = 8
   - Peat and heavy organic = 9
   - Frozen/permafrost = 0
7. Number of logs larger than 6"
   3 = 03, 10 = 10, etc.
8. Number of logs 3" to 6"
   Same as above

V. Type of line construction
1. Line width. Enter the line width to the nearest half foot.
   4.5 ft = 045, 13.5 = 135, etc.
2. Clearing width. Enter 3 ft = 003, 27 ft = 027, 122 ft = 122, etc.
3. Direction of line construction
   - Upslope = 1
   - Downslope = 2
   - Angle, up = 3
   - Angle, down = 4
   - Cross slope or level = 5

(con.)

4. Fireline grade. +40% = 040, –40% = –40, over +99% = 099, over a –99% = –99, etc.
5. General type of line
   - Scratch = 1
   - Wet line = 2
   - Black line = 3
   - Reinforced = 4
   - Mineral soil = 5
   - Mineral soil with clearing = 6
   - Mineral soil with clearing and limbing = 7
   - Retardant only = 8
   - Mineral soil reinforced with retardant = 9

VI. Fire behavior

1. General character
   - Cold (no fire) = 0
   - Smoldering = 1
   - Creeping = 2
   - Running = 3
   - Spotting = 4
   - Crowning = 5
2. Flame length. Enter to the nearest 0.5 ft 2.5 ft = 025, 15 ft = 150, etc.
3. Flame depth. Enter to the nearest ft 1 ft = 01, 11 ft = 11, etc.
4. Rate of spread. Enter to the nearest ft 2 ft/min = 002, 13 ft/min = 013, etc.

VII. Observation

1. Length of line constructed. Enter to the nearest ft.
   75 ft = 0075, etc.
2. Time to construct. Enter the total minutes.
   25 min = 025, 1 hr and 43 min = 103, etc.

VIII. Travel

1. Enter in whole hours. 4 hrs = 04, 23 hrs = 23, etc.
2. Mode of travel

Walk = 1	Tour (type) bus = 6
Horseback = 2	Truck = 7
Airplane = 3	Auto or pickup = 8
Helicopter = 4	Boat = 9
School bus = 5	

APPENDIX D: DATA LISTING AND DATA LAYOUT

Data Table Key

Column numbers	Column identification (See data coding instructions (appendix C) for further detail)
1-3	Observation ID number
4-9	Date
10-11	Time
12-13	Number of persons
	Type and number of tools:
14	Type
15-16	How many
17	Type
18-19	How many
20	Type
21-22	How many
23	Type
24-25	How many
26	Type of crew
27	Experience level
28	Hours on line
29-30	Days on this fire
31-32	Temperature
33-34	Relative humidity
35-36	Wind speed
37-39	Energy release component (only in 1982)
40-41	Spread component (only in 1982)
42	Fuel type, general
43	Fuel type, burning
44	Ground material
45-46	Fuel model (1982 data), Duff depth (1983-84 data)
47-48	Slope
49	Soil type
50-51	Number of logs larger than 6"
52-53	Number of logs 3" to 6"
54-56	Line width
57-59	Clearing width
60	Direction of line construction
61-63	Fireline grade
64	General type of line
65	Fire behavior
66-68	Flame length
69-70	Flame depth
71-73	Rate of spread
74-77	Length of line constructed
78-80	Time to construct
81-84	Rate of line construction (feet/minute)
85	Number of photographs (1982 data only)
86-87	Travel time to fire
88	Mode of travel

Each row represents one observation, entered in no particular order.

(con.)

1-3	4-9	10-11	12-13	14	15-16	17	18-19	20	21-22	23	24-25	26	27	28	29-30	31-32	33-34	35-36	37-39	40-41	42	43	44
001	061282	11	19	2	9	1	8	6	7	2	5	2	3	5	1	75	12	8	0	0	1	1	2
002	061282	11	22	1	8	2	9	5	2	6	1	3	5	9	1	75	12	8	0	0	1	1	2
003	071482	13	20	5	3	1	13	2	1	0	0	3	4	0	0	55	0	10	0	0	1	0	1
004	071482	11	20	1	14	2	1	5	2	0	0	3	4	0	0	52	78	15	0	0	1	0	3
005	081882	8	18	1	16	2	2	0	0	0	0	3	5	1	1	80	35	2	0	0	1	3	2
006	081882	9	11	1	10	2	1	0	0	0	0	3	5	2	1	80	35	2	0	0	1	3	2
007	062682	12	18	2	8	1	8	5	2	0	0	3	6	2	1	80	20	10	0	0	2	1	8
008	062882	18	18	5	2	2	7	1	7	6	2	3	6	1	1	72	20	8	0	0	2	4	1
009	071682	2	17	5	3	1	7	2	7	0	0	3	6	3	1	50	10	10	0	0	2	5	2
010	072382	12	18	5	3	2	7	1	7	0	0	3	6	5	1	72	54	5	0	0	4	2	1
011	082782	17	20	1	16	2	4	0	0	0	0	3	4	9	1	82	16	10	0	0	8	3	2
012	080882	13	12	1	6	2	5	6	1	0	0	3	4	5	1	70	5	5	0	0	7	2	2
013	061082	21	14	1	7	2	5	5	2	0	0	3	5	9	1	60	20	5	0	0	6	9	2
014	062882	8	20	1	12	2	8	0	0	0	0	3	4	4	1	90	18	5	0	0	7	3	2
015	072182	8	20	5	2	1	11	2	7	0	0	3	5	1	9	90	15	9	0	0	5	8	2
016	072282	8	14	1	8	2	4	5	2	0	0	3	3	9	9	90	10	5	0	0	5	8	2
017	080182	20	20	1	11	2	6	6	1	5	2	3	3	9	2	65	17	5	0	0	7	2	1
018	082082	20	15	1	9	2	6	0	0	0	0	3	3	9	1	80	23	13	0	0	7	2	2
019	082482	11	1	1	1	0	0	0	0	0	0	3	4	1	0	60	41	3	0	0	1	0	2
020	082482	11	1	1	1	0	0	0	0	0	0	3	4	1	0	60	41	3	0	0	1	0	2
021	082482	11	1	1	1	0	0	0	0	0	0	3	4	1	0	60	41	2	0	0	1	0	2
022	082482	11	2	1	2	6	1	0	0	0	0	3	4	1	0	60	41	3	0	0	1	0	2
023	082482	11	2	1	2	2	1	0	0	0	0	3	4	1	0	60	41	3	0	0	1	0	2
024	082482	11	4	1	4	2	1	0	0	0	0	3	4	1	0	60	41	2	0	0	1	0	2
025	082482	11	8	1	5	5	1	6	1	0	0	3	4	1	0	60	41	3	0	0	1	0	2
026	082482	1	19	5	2	1	14	2	2	0	0	3	4	1	0	70	0	4	0	0	1	0	2
027	082782	9	1	1	1	0	0	0	0	0	0	3	4	1	0	64	44	0	0	0	7	0	8
028	082782	9	1	1	1	0	0	0	0	0	0	3	4	0	0	64	44	0	0	0	7	0	4
029	082782	9	1	1	1	0	0	0	0	0	0	3	4	0	0	64	44	0	0	0	7	0	1
030	082782	9	2	1	2	0	0	0	0	0	0	3	4	0	0	64	44	0	0	0	1	0	8
031	082782	9	2	1	2	0	0	0	0	0	0	3	4	0	0	64	44	0	0	0	1	0	1
032	082782	9	4	1	4	5	1	0	0	0	0	3	4	0	0	64	44	0	0	0	1	0	1
033	082782	9	8	1	7	5	1	0	0	0	0	3	4	0	0	64	44	0	0	0	1	0	8
034	082782	1	20	5	1	1	16	2	1	0	0	3	4	1	0	73	50	0	0	0	1	0	8
035	090282	11	1	1	1	0	0	0	0	0	0	3	4	0	0	61	54	0	0	0	1	0	8
036	090282	11	1	1	1	0	0	0	0	0	0	3	4	0	0	61	54	0	0	0	1	0	8
037	090282	11	1	1	1	0	0	0	0	0	0	3	4	0	0	61	54	0	0	0	1	0	8
038	090282	11	2	1	2	0	0	0	0	0	0	3	4	0	0	61	54	0	0	0	1	0	8
039	090282	12	2	1	2	0	0	0	0	0	0	3	4	0	0	61	54	0	0	0	1	0	8
040	090282	12	4	1	3	2	1	0	0	0	0	3	4	0	0	61	54	0	0	0	1	0	8
041	090282	11	8	5	1	6	1	1	6	0	0	3	4	0	0	61	54	0	0	0	1	0	8
042	090282	2	20	6	2	1	16	2	1	5	1	3	4	1	0	61	54	0	0	0	1	0	8
043	071882	7	21	1	10	2	10	5	3	0	0	3	4	9	2	85	18	15	0	0	7	2	1
044	011782	21	20	2	12	1	8	3	4	0	0	3	2	2	1	75	20	15	0	0	7	2	1
045	081882	2	20	2	16	1	10	3	6	0	0	3	2	7	1	70	25	15	0	0	7	2	1
046	081882	4	26	2	16	1	10	3	6	0	0	3	2	9	1	60	40	10	0	0	7	2	2
047	071982	6	18	5	2	1	12	2	4	0	0	3	4	9	1	48	75	5	0	0	8	4	1
048	081082	9	13	1	9	2	0	6	1	6	3	3	4	1	1	65	45	0	0	0	7	0	1
049	081082	12	14	1	10	6	1	6	3	0	0	3	4	3	1	72	40	12	0	0	7	0	1
050	081082	13	19	1	11	2	2	6	1	6	3	3	4	4	10	70	40	15	0	0	7	0	8
051	081082	14	15	1	9	0	0	6	1	6	3	3	4	5	1	75	40	15	0	0	7	0	1
052	081082	15	14	1	10	6	3	6	1	0	0	3	4	8	1	72	40	3	0	0	7	0	0
053	080682	1	20	0	0	1	10	2	10	0	0	3	4	5	1	75	24	2	0	0	7	0	1
054	080682	3	20	0	0	1	10	2	10	0	0	3	4	7	1	75	24	2	0	0	7	0	1
055	080682	1	20	0	0	1	10	2	10	0	0	3	4	4	1	78	22	2	0	0	7	0	1
056	080582	24	20	0	0	1	10	2	10	0	0	3	4	2	1	78	22	2	0	0	7	0	2
057	091382	11	8	1	1	2	1	0	0	0	0	3	2	3	1	48	0	10	0	0	7	0	2
058	091482	11	3	5	3	0	0	0	0	0	0	3	3	0	0	55	0	5	0	0	1	0	1
059	091482	12	16	5	6	1	2	2	2	0	0	3	3	2	0	50	0	7	0	0	1	0	1
060	072983	13	20	5	2	1	6	2	10	6	2	3	4	4	1	75	10	20	0	0	3	8	2
061	072883	20	20	5	2	1	8	2	8	6	2	3	4	2	1	99	9	15	0	0	3	2	1
062	071783	21	20	5	2	1	9	2	7	6	2	3	4	3	5	**	8	20	0	0	1	8	2
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065	070883	10	19	5	1	1	8	2	8	6	2	3	4	4	4	**	10	35	0	0	8	3	1
066	070783	14	19	5	2	1	8	2	7	6	2	3	4	5	4	**	12	50	0	0	7	2	2
067	072383	11	20	2	5	5	3	6	7	6	3	3	5	9	1	90	27	13	0	0	7	2	1
068	071583	21	5	5	1	6	2	2	1	0	0	3	4	5	7	73	65	3	0	0	7	4	*
069	071383	13	20	2	5	5	3	6	8	6	2	3	5	9	1	85	0	3	0	0	7	2	*
070	071283	13	9	2	2	5	1	6	4	6	1	3	5	9	1	93	0	3	0	0	7	2	*
071	071183	13	10	2	2	5	2	6	5	6	1	3	6	9	1	99	0	3	0	0	7	7	*
072	071083	14	20	2	5	5	3	6	8	6	2	3	5	9	0	78	0	18	0	0	7	7	*
073	070783	20	20	2	5	5	2	6	9	6	2	3	5	9	0	63	35	1	0	0	7	4	1
074	070783	20	20	2	5	5	2	6	9	6	2	3	4	9	0	63	35	1	0	0	7	7	1
075	062183	16	20	2	5	5	2	6	9	6	2	3	5	6	0	80	27	6	0	0	7	2	1
076	061983	23	19	2	5	5	2	6	8	6	2	3	5	9	1	94	20	5	0	0	7	2	1
077	061683	12	20	2	5	5	2	6	9	6	2	3	5	5	0	85	33	6	0	0	7	2	1
078	052683	18	20	2	5	5	2	6	9	6	2	3	5	9	1	99	25	3	0	0	7	2	1
079	071483	11	10	1	6	6	4	0	0	0	0	3	2	8	0	50	50	15	0	0	1	*	*
080	081783	10	7	1	5	5	2	2	1	0	0	3	3	2	**	60	40	5	0	0	1	*	2
081	071483	10	10	6	6	4	1	0	0	0	0	3	2	8	50	50	15	1	0	0	1	*	8
082	060983	16	2	2	1	1	1	0	0	0	0	2	6	4	0	72	18	0	0	0	1	5	1
083	071283	16	10	2	5	1	5	5	1	3	4	2	*	5	1	**	**	0	0	0	5	5	2
084	070283	6	4	2	2	1	2	0	0	0	0	2	*	6	1	**	20	40	0	0	5	8	1
085	062683	15	6	1	1	2	2	6	3	0	0	2	*	8	1	80	15	20	0	0	1	8	2
086	080683	22	8	2	4	1	4	5	2	3	5	2	*	8	1	**	20	10	0	0	1	8	2
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45-46	47-48	49	50-51	52-53	54-56	57-59	60	61-63	64	65	66-68	69-70	71-73	74-77	78-80	81-84	85	86-87	88
10	2	6	5	10	2	8	1	2	3	5	5	66	10	3960	180	220	0	1	5
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7	80	6	6	1	25	10	5	15	7	0	0	0	0	462	82	56	1	1	8
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3	75	6	0	0	15	0	1	15	5	0	0	0	0	208	56	30	1	1	8
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7	56	3	0	0	15	0	1	50	5	0	0	0	0	229	108	21	1	1	8
7	50	3	0	0	15	0	1	50	5	0	0	0	0	215	84	25	1	1	8
7	25	3	0	0	15	0	3	25	5	0	0	0	0	498	122	41	1	1	8
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12	80	6	0	0	35	1	1	60	6	3	40	3	100	500	240	21	0	1	5
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0	10	2	0	0	20	6	2	-10	6	1	0	0	0	300	25	120	0	4	5
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0	60	2	0	0	20	6	2	-60	6	1	0	0	0	90	60	15	0	4	8
0	40	1	21	40	20	8	0	0	5	0	0	0	0	462	180	26	0	0	0
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0	45	5	60	63	0	15	0	45	5	0	0	0	0	528	150	35	0	0	0
1	99	7	34	48	30	6	1	99	4	3	15	10	96	282	70	40	0	0	6
1	85	5	4	**	30	5	1	99	3	2	8	5	11	95	30	32	0	2	8
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3	30	5	0	2	20	3	5	99	6	0	0	0	0	300	90	33	0	5	4
9	45	5	0	0	30	9	5	58	6	3	25	15	30	2300	720	32	0	3	4
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5	99	6	0	0	50	10	5	47	6	1	0	0	1	1500	480	31	0	2	7
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2	99	3	0	0	30	5	5	99	6	2	2	2	3	2500	240	104	0	1	7
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3	30	6	**	**	20	13	2	30	7	0	0	0	0	660	70	94	0	1	8
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1-3	4-9	10-11	12-13	14	15-16	17	18-19	20	21-22	23	24-25	26	27	28	29-30	31-32	33-34	35-36	37-39	40-41	42	43	44
088	073183	11	2	2	1	1	1	5	1	3	4	2	*	8	1	**	35	10	0	0	1	8	2
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090	062683	10	4	1	3	5	1	0	0	0	0	1	6	0	0	**	**	3	0	0	*	*	*
091	062683	9	4	1	3	5	1	2	1	0	0	1	6	0	0	**	**	0	0	0	2	*	2
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093	081083	11	7	6	1	0	0	0	0	0	0	7	1	*	**	75	57	2	0	0	8	*	1
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096	081083	15	8	6	1	0	0	0	0	0	0	7	1	*	**	86	36	2	0	0	2	*	1
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098	081083	**	8	6	1	0	0	0	0	0	0	7	1	*	**	87	39	2	0	0	2	*	1
099	081083	17	7	6	1	0	0	0	0	0	0	7	1	*	**	83	36	0	0	0	2	*	1
100	081083	17	7	6	1	0	0	0	0	0	0	7	1	*	**	83	36	0	0	0	2	*	1
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102	081083	17	7	6	1	0	0	0	0	0	0	7	1	*	**	80	40	**	0	0	2	*	1
103	081083	**	8	6	1	0	0	0	0	0	0	7	1	*	**	8	44	2	0	0	2	*	1
104	071783	2	12	1	5	2	5	5	1	0	0	7	1	9	6	**	**	**	0	0	1	8	2
105	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~
106	071583	15	12	1	8	2	4	0	0	0	0	7	2	9	4	**	**	**	0	0	7	2	2
107	071883	14	13	1	4	2	3	6	1	5	3	7	1	8	**	**	**	**	0	0	1	4	2
108	071683	16	12	1	8	2	1	5	3	0	0	7	1	9	5	**	**	**	0	0	5	8	2
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111	080583	17	17	5	1	1	13	2	2	1	1	3	4	*	**	90	28	3	0	0	1	5	1
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120	091283	13	18	1	9	2	1	6	4	5	3	3	4	2	0	40	40	15	0	0	1	0	1
121	080883	14	7	1	6	5	1	0	0	0	0	1	6	6	1	99	10	5	0	0	1	2	2
122	080683	18	6	1	6	5	1	0	0	0	0	1	6	3	1	98	50	0	0	0	1	4	2
123	060683	20	12	1	12	5	1	0	0	0	0	1	8	9	5	0	0	10	0	0	1	3	1
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125	080483	12	10	1	10	6	10	0	0	0	0	1	5	8	3	99	13	7	0	0	1	1	1
126	062483	21	4	1	4	0	0	0	0	0	0	1	9	9	1	90	10	2	0	0	7	3	1
127	070883	15	10	1	10	5	1	0	0	0	0	1	9	9	2	99	15	10	0	0	1	4	1
128	082983	18	2	1	2	2	1	6	1	0	0	1	9	8	3	85	40	5	0	0	1	4	2
129	073083	17	4	1	3	2	2	0	0	0	0	1	7	9	2	74	36	10	0	0	1	2	1
130	081183	7	2	1	2	2	1	6	1	0	0	1	9	0	2	70	50	15	0	0	1	4	2
131	080583	14	3	1	2	2	1	5	1	0	0	1	8	9	2	0	0	0	0	0	1	4	1
132	072483	13	10	1	4	6	4	2	2	0	0	1	5	5	1	95	30	10	0	0	8	3	1
133	071983	18	2	1	2	5	1	3	2	0	0	1	9	9	3	68	30	5	0	0	5	3	2
134	082383	2	30	1	26	2	4	3	6	0	0	1	6	9	3	90	52	7	0	0	2	4	1
135	080183	19	4	1	4	2	2	5	1	0	0	1	9	9	2	85	0	11	0	0	1	4	1
136	080783	19	2	1	2	2	1	6	1	0	0	1	9	5	2	0	0	0	0	0	1	4	1
137	080883	17	2	1	2	2	1	6	1	0	0	1	9	1	1	0	0	10	0	0	1	3	1
138	080383	16	2	1	2	0	0	0	0	0	0	1	7	1	1	0	0	3	0	0	1	4	1
139	081383	19	2	1	2	2	1	6	1	0	0	1	9	1	2	85	0	3	0	0	1	4	1
140	080483	11	4	1	4	2	1	0	0	0	0	1	9	3	2	95	0	5	0	0	1	3	1
141	070684	13	20	5	3	1	9	2	8	0	0	3	5	6	1	98	0	0	0	0	7	2	8
142	070984	14	20	5	2	1	9	2	8	6	1	3	5	8	1	0	0	0	0	0	1	4	1
143	071084	15	20	5	3	1	10	2	6	6	1	3	5	9	2	80	0	13	0	0	1	4	1
144	071184	10	20	5	3	2	8	1	8	6	1	3	5	4	3	90	0	0	0	0	7	2	2
145	071284	10	20	5	3	2	7	1	9	6	1	3	5	4	4	92	0	0	0	0	7	2	2
146	080884	1	19	5	3	1	5	2	7	6	1	3	5	4	1	80	0	6	0	0	7	2	1
147	080784	22	19	5	3	1	5	2	7	6	1	3	5	1	1	85	0	9	0	0	7	2	1
148	080284	10	18	5	3	1	7	2	8	6	1	3	5	4	1	87	0	0	0	0	7	2	2
149	072284	12	29	5	2	1	24	2	1	0	0	1	8	6	1	0	0	0	0	0	1	*	1
150	072284	0	28	1	22	5	2	2	1	6	3	1	0	3	1	0	0	0	0	0	1	*	1
151	071284	0	20	5	3	1	12	6	5	0	0	1	8	9	5	0	0	0	0	0	1	3	1
152	081184	0	8	1	7	5	1	0	0	0	0	1	9	6	3	90	15	13	0	0	1	1	1
153	073084	17	10	1	10	2	2	0	0	0	0	1	9	9	1	0	6	25	0	0	7	3	2
154	080684	11	19	1	18	6	1	0	0	0	0	1	9	8	2	0	20	5	0	0	7	3	1
155	071584	21	5	1	5	1	1	0	0	0	0	1	9	4	1	85	20	3	0	0	1	5	1
156	070884	3	10	6	1	5	1	1	8	0	0	1	0	4	2	0	0	0	0	0	1	5	8
157	082984	0	40	1	20	2	18	5	2	0	0	5	0	9	1	0	0	0	0	0	1	2	1
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159	083184	0	18	1	9	2	9	5	2	0	0	5	0	7	3	0	0	0	0	0	5	3	9
160	090184	13	37	1	35	2	2	0	0	0	0	5	2	8	3	0	40	2	0	0	1	2	2
161	062584	11	20	1	10	2	10	0	0	0	0	5	3	9	1	87	22	7	0	0	1	4	1
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166	082484	0	2	1	2	0	0	0	0	0	0	1	6	9	2	0	0	0	0	0	5	2	1
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168	081484	14	3	3	1	3	6	0	0	0	0	1	9	5	1	90	10	3	0	0	8	3	1
169	081384	16	6	1	5	5	1	0	0	0	0	1	8	9	4	90	20	10	0	0	1	2	1
170	081084	13	2	1	2	0	0	0	0	0	0	1	9	9	2	0	20	0	0	0	1	2	1
171	081084	15	2	1	2	0	0	0	0	0	0	1	9	2	2	0	0	0	0	0	1	2	2
172	081384	21	6	1	5	5	1	0	0	0	0	1	4	9	4	0	0	0	0	0	1	4	1
173	081584	19	13	1	11	5	2	0	0	0	0	1	3	0	0	0	0	5	0	0	1	4	1

45-46	47-48	49	50-51	52-53	54-56	57-59	60	61-63	64	65	66-68	69-70	71-73	74-77	78-80	81-84	85	86-87	88
0	25	1	0	0	30	1	1	25	1	2	2	1	1	50	15	33	0	0	4
3	7	5	1	3	30	0	1	7	9	1	5	2	6	300	30	100	0	0	4
3	0	5	4	7	20	0	0	0	5	0	0	0	0	100	10	100	0	0	*
2	0	3	7	5	20	0	0	0	5	0	0	0	0	100	11	91	0	**	*
3	5	5	3	2	30	0	5	5	4	0	0	0	0	100	12	83	0	**	*
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**	0	5	0	0	10	2	5	***	*	0	0	0	0	80	18	44	0	**	*
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**	0	5	**	**	10	2	1	***	*	0	0	0	0	80	27	29	0	**	*
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**	2	5	**	**	10	2	*	***	*	0	0	0	0	130	15	87	0	**	*
**	2	5	**	**	10	2	*	***	*	0	0	0	0	120	19	63	0	**	*
**	2	5	**	**	10	2	*	***	*	0	0	0	0	400	12	333	0	**	*
**	0	5	**	**	10	2	1	***	*	0	0	0	0	80	34	23	0	**	*
4	45	6	20	50	30	2	4	45	6	3	20	6	6	20	20	10	0	4	5
~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~
**	20	6	0	0	30	10	1	20	3	3	30	20	60	2000	240	83	0	**	*
6	30	6	2	1	20	5	1	35	6	2	2	25	***	700	135	52	0	3	1
4	80	6	15	5	30	75	1	80	6	5	50	10	10	200	180	11	0	2	1
0	5	6	0	0	20	3	5	5	3	3	5	3	10	900	140	64	0	3	5
1	10	7	0	0	30	5	5	10	6	2	1	3	***	150	20	75	0	4	5
3	40	5	3	6	15	3	1	40	3	*	***	**	***	820	18	456	0	**	*
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4	50	5	0	0	10	2	2	-50	5	*	***	**	***	296	63	47	0	**	*
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3	10	5	0	0	10	2	5	0	5	0	0	0	0	305	56	55	0	0	0
4	50	5	0	0	10	2	2	50	5	0	0	0	0	224	63	36	0	0	0
3	20	5	0	0	10	2	5	0	5	0	0	0	0	1082	57	190	0	0	0
1	20	0	0	0	10	15	2	0	0	0	0	0	0	6534	210	311	0	1	7
0	45	6	13	8	20	14	5	0	0	0	0	0	0	748	120	62	0	1	7
4	85	6	1	1	20	10	2	85	3	2	10	1	3	400	30	130	0	2	3
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3	80	6	8	1	10	0	1	80	5	3	1	2	2	264	45	59	0	1	3
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1	10	5	0	2	10	4	0	0	4	3	20	3	0	5280	420	126	0	5	3
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8	30	7	1	5	15	5	0	20	7	2	10	1	0	250	300	8	0	2	3
3	10	6	2	7	15	1	1	10	6	2	0	0	0	330	120	28	0	2	3
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3	30	5	2	5	30	11	0	0	6	2	10	1	2	440	165	27	0	1	8
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2	50	6	0	1	30	9	5	40	6	0	0	0	0	3960	480	82	0	1	4
2	60	6	1	4	35	11	1	50	6	2	0	0	0	440	150	29	0	2	8
3	80	5	1	1	35	11	1	70	6	4	0	0	11	550	140	39	0	2	8
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1	25	2	0	0	10	3	5	10	1	2	10	2	1	1000	45	222	0	2	3
8	30	5	15	5	15	6	0	5	6	2	25	1	0	275	60	46	0	1	3
2	40	6	0	1	15	3	5	40	7	2	5	1	1	1914	140	137	0	2	3
2	70	8	0	0	20	6	3	70	4	2	10	1	1	3960	660	60	0	1	7
2	30	8	0	0	20	6	3	30	4	2	10	1	1	1000	300	33	0	5	4
2	50	8	0	0	20	6	3	54	0	0	0	0	0	800	420	19	0	1	4
3	70	6	8	20	15	3	0	70	4	2	10	2	10	500	180	44	0	1	4
2	50	0	0	0	20	6	5	10	6	2	15	0	0	1900	155	122	0	7	7
5	85	9	1	0	20	3	5	85	9	1	20	0	0	462	480	10	0	1	4
4	20	5	1	6	10	0	3	15	1	1	5	1	0	100	60	17	0	4	4
0	40	7	0	0	5	0	5	40	1	3	30	1	10	500	30	167	0	3	5
4	50	1	1	2	10	6	0	50	1	3	40	4	2	650	50	130	0	1	3
0	60	1	13	0	10	2	0	60	3	1	0	0	0	15	30	5	0	2	3
6	30	5	9	11	15	4	5	10	5	2	5	1	1	265	240	11	0	2	3
0	40	3	0	0	0	0	2	0	1	3	20	3	30	660	60	110	0	1	3
3	75	3	2	3	15	10	0	50	7	4	35	5	4	1800	300	60	0	1	3
2	45	0	2	3	15	3	0	0	1	0	10	0	0	400	120	33	0	1	3
1	30	5	1	2	15	4	2	15	5	1	0	0	0	125	60	21	0	1	3
1	0	5	0	1	15	4	0	20	7	1	0	0	0	1980	240	82	0	2	7
1	20	6	0	0	10	3	0	0	7	2	10	2	0	3700	360	103	0	1	1

Barney, Richard J.; George, Charles W.; Trethewey, Diane L. 1992. Handcrew fireline production rates—some field observations. Res. Pap. INT-457. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 25 p.

The results of a study of handcrew fireline production rates are presented. The methods are discussed. A series of tables and figures are presented showing the data collected and analyzed in a variety of stratifications. The basic data from the study are also presented. Because of the limited data set of 160 observations, it was not possible to develop a detailed production model. However, the data do show some interesting relationships. The authors recommend further study to enhance these as well as previous efforts.

KEYWORDS: fire control, fire fighting, fire suppression, forest fires, fireline construction, fire crews, smokejumpers, hotshot crews, Intermountain West

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